

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listing, of claims in the application.

- 1 1. (Currently Amended) A signal filtering mechanism, comprising:
2 a Kalman filter capable of receiving an input signal, a measured quantity signal, and a
3 variance estimate signal for the measured quantity signal, and outputting a state
4 estimate signal; and
5 a variance estimator capable of estimating the variance of the measured quantity signal
6 and generating the variance estimate signal for use in filtering the input signal and
7 the measured quantity signal, wherein estimating the variance of the measured
8 quantity signal includes determining a smoothed estimate of the measured
9 quantity's final variance from the measured quantity signal.
- 1 2. (Original) The signal filtering mechanism of claim 1, wherein determining the smoothed
2 estimate comprises:
3 determining the squared instantaneous prediction error of the measured quantity signal;
4 smoothing the determined, squared instantaneous prediction error; and
5 estimating the measured quantity's variance from the smoothed squared instantaneous
6 prediction error.
- 1 3. (Original) The signal filtering mechanism of claim 1, wherein determining the smoothed
2 estimate comprises:
3 determining the absolute instantaneous prediction error in the measured quantity signal;
4 smoothing the determined, absolute instantaneous prediction error; and
5 estimating the measured quantity's variance from the smoothed absolute instantaneous
6 prediction error.
- 1 4. (Original) A method for estimating the variance of a measured quantity used to predict
2 the current state of a discrete, vector-state, scalar-measurement system, the method comprising:
3 estimating the variance of a measured quantity for use in filtering an input quantity and
4 the measured quantity;

5 determining a smoothed estimate of an instantaneous prediction error's variance; and
6 filtering the input quantity and the measured quantity through a Kalman filter using the
7 estimated input variance of the measured quantity signal.

1 5. (Original) The method of claim 4, wherein determining the smoothed estimate of the
2 variance of the instantaneous prediction error of the measured quantity signal comprises:
3 determining the squared instantaneous prediction error in the measured quantity signal;
4 smoothing the determined, squared instantaneous prediction error; and
5 estimating the variance from the smoothed squared instantaneous prediction error.

1 6. (Original) The method of claim 5, further comprising initializing a plurality of quantities
2 used in estimating the current state of the discrete, vector-state, scalar-measurement system.

1 7. (Original) The method of claim 6, wherein initializing the plurality of quantities includes:
2 setting the prediction of the initial state of the system to a first predetermined value; and
3 setting the initial prediction covariance matrix associated with the predicted initial state
4 of the system to a second predetermined value; and
5 one of:
6 setting the error filter gain to a third predetermined value; or
7 setting the smoothed squared instantaneous prediction error to 0.

1 8. (Original) The method of claim 7, wherein the third predetermined value is a vector of
2 ones.

1 9. (Original) The method of claim 7, wherein the error filter gain is set to a third
2 predetermined value and filtering the input quantity and the measured quantity includes
3 determining a Kalman filter gain vector, a current state vector estimate, and a state vector
4 estimate covariance matrix after estimating the variance of the measured quantity.

1 10. (Original) The method of claim 7, wherein the smoothed squared instantaneous
2 prediction error is set to 0 and filtering the input quantity and the measured quantity includes
3 determining a Kalman filter gain vector, a current state vector estimate, and a state vector
4 estimate covariance matrix before estimating the variance.

1 11. (Original) The method of claim 4, wherein determining the smoothed estimate of the
2 variance of the instantaneous prediction error of the measured quantity signal comprises:

3 determining the absolute instantaneous prediction error in the measured quantity signal;
4 smoothing the determined, absolute instantaneous prediction error; and
5 estimating the variance from the smoothed absolute instantaneous prediction error.

1 12. (Original) The method of claim 11, further comprising initializing a plurality of quantities
2 used in estimating the current state of the discrete, vector-state, scalar-measurement system.

1 13. (Original) The method of claim 12, wherein initializing the plurality of quantities
2 includes:

3 setting the prediction of the initial state of the system to a first predetermined value; and
4 setting the initial prediction covariance matrix associated with the predicted initial state
5 of the system to a second predetermined value; and

6 one of:

7 setting the error filter gain to a third predetermined value; or
8 setting the smoothed absolute instantaneous prediction error to 0.

1 14. (Original) The method of claim 13, wherein the third predetermined value is a vector of
2 ones.

1 15. (Original) The method of claim 13, wherein the error filter gain is set to a third
2 predetermined value and filtering the input quantity and the measured quantity includes
3 determining a Kalman filter gain vector, a current state vector estimate, and a state vector
4 estimate covariance matrix after estimating the variance of the measured quantity.

1 16. (Original) The method of claim 13, wherein the smoothed absolute instantaneous
2 prediction error is set to 0 and filtering the input quantity and the measured quantity includes
3 determining a Kalman filter gain vector, a current state vector estimate, and a state vector
4 estimate covariance matrix before estimating the variance.

1 17. (Currently Amended) A method for estimating the current state of a discrete, vector-state,
2 scalar-measurement system, the method comprising:

3 determining a current state vector prediction from a previous state vector estimate and an
4 input vector;
5 determining a current state vector prediction covariance matrix associated with the
6 current state vector prediction from a previous state vector covariance matrix
7 associated with the previous state vector estimate;
8 estimating the variance of a measured quantity, wherein estimating the variance includes:
9 determining a squared instantaneous prediction error of the measured quantity
10 from the measured quantity and one of the current state vector estimate
11 and the previous state vector estimate;
12 smoothing the squared instantaneous prediction error; and
13 estimating the final variance of the measured quantity from the smoothed squared
14 instantaneous prediction error;
15 determining a current Kalman filter gain vector from the current state vector prediction
16 covariance matrix and the measured quantity variance estimate;
17 determining a current state vector estimate from the Kalman filter gain, the current state
18 vector prediction, and the measured quantity;
19 determining the current state vector covariance matrix associated with the current state
20 vector estimate from the Kalman filter gain and the current state vector prediction
21 covariance matrix; and
22 iterating the above.

1 18. (Original) The method of claim 17, further comprising initializing a plurality of quantities
2 used in estimating the current state of the discrete, vector-state, scalar-measurement system.

1 19. (Original) The method of claim 18, wherein initializing the plurality of quantities
2 includes:

3 setting the value of the current state vector prediction to a first predetermined value;
4 setting the current state vector prediction covariance matrix to a second predetermined
5 value; and
6 performing one of:
7 setting an error filter gain to a third predetermined value; or
8 setting the squared instantaneous prediction error to 0.

1 20. (Original) The method of claim 17, wherein the current state vector estimate, the current
2 state vector prediction covariance matrix, and the current Kalman filter gain are updated after the
3 variance of the measured quantity is estimated.

1 21. (Original) The method of claim 20, wherein, in estimating the variance of the measured
2 quantity includes:

determining the squared instantaneous prediction error in the measured quantity includes applying the following analysis:

$$e^2[n] = (z[n] - H[n]\hat{x}[n \mid n-1])^2;$$

smoothing the determined, squared instantaneous prediction error includes applying the following analysis:

$$\hat{\sigma}_e^2[n] = \hat{\sigma}_e^2[n-1] + H[n]G[n]\left(e^2[n] - \hat{\sigma}_e^2[n-1]\right); \text{ and}$$

estimating the variance of the measured quantity from the smoothed squared instantaneous prediction error comprises:

11 setting the estimated variance to a fourth predetermined value if the Kalman filter
12 is not stable; or

13 applying the following analysis if the Kalman filter is stable:

determining the value of $a[n]$ from:

$$a[n] = \frac{H[n]A[n]H[n]^T}{H[n]H[n]^T};$$

determining the value of $q[n]$ from:

$$q[n] = (H[n]B[n])Q[n](H[n]B[n])^T; \text{ and}$$

solving for $\hat{R}[n]$ from

$$\hat{R}[n]^2 \left(2a^2[n] - 1 \right) + \hat{R}[n] \left[\hat{\sigma}_e^2[n] \left(1 - 3a^2[n] \right) - 2q[n] \right] + \hat{\sigma}_e^2[n] \left(q[n] + \hat{\sigma}_e^2[n] a^2[n] \right) = 0.$$

1 22. (Original) The method of claim 17, wherein the current state vector estimate, the current
2 state vector prediction covariance matrix, and the current Kalman filter gain are updated before
3 the variance of the measured quantity is estimated.

23. (Original) The method of claim 22, wherein, in estimating the variance of the measured quantity includes:

determining the squared instantaneous prediction error of the measured quantity includes applying the following analysis:

$$e^2[n] = (z[n] - H[n]\hat{x}[n])^2;$$

smoothing the determined, squared instantaneous prediction error includes applying the following analysis:

$$\hat{\sigma}_e^2[n] = \hat{\sigma}_e^2[n-1] + H[n]G[n]\left(e^2[n] - \hat{\sigma}_e^2[n-1]\right); \text{ and}$$

estimating the variance from the smoothed squared instantaneous prediction error comprises:

setting the estimated variance to a fourth predetermined value if the Kalman filter is not stable; or

applying the following analysis if the Kalman filter is stable:

determining the value of $a[n]$ from:

$$a[n] = \frac{H[n]A[n]H[n]^T}{H[n]H[n]^T};$$

determining the value of $q[n]$ from:

$$q[n] = (H[n]B[n])Q[n](H[n]B[n])^T; \text{ and}$$

solving for $\hat{R}[n]$ from

$$\hat{R}[n]^4 \frac{a^2[n]}{\left(\hat{\sigma}_e^2[n]\right)^2} + \hat{R}[n]^3 \frac{1-3a^2[n]}{\hat{\sigma}_e^2[n]} + \hat{R}[n]^2 \left(2a^2[n]-1\right) \left(1 - \frac{q[n]}{\hat{\sigma}_e^2[n]}\right) + \left(\hat{R}[n]3q[n] + q^2[n]\right)\left(a^2[n]-1\right) = 0.$$

24. (Original) A signal filtering mechanism, comprising:

means for receiving an input signal, a measured quantity signal, and a variance estimate signal for the measured quantity signal, and outputting a state estimate signal; and means for estimating the variance of the measured quantity signal and generating the variance estimate signal for use in filtering the input signal and the measured

6 quantity signal, wherein estimating the variance of the measured quantity signal
7 includes determining a smoothed estimate of the measured quantity's final
8 variance from the measured quantity signal.

1 25. (Original) The signal filtering mechanism of claim 24, wherein determining the smoothed
2 estimate comprises:

3 determining the squared instantaneous prediction error of the measured quantity signal;
4 smoothing the determined, squared instantaneous prediction error; and
5 estimating the measured quantity's variance from the smoothed squared instantaneous
6 prediction error.

1 26. (Original) The signal filtering mechanism of claim 24, wherein determining the smoothed
2 estimate comprises:

3 determining the absolute instantaneous prediction error in the measured quantity signal;
4 smoothing the determined, absolute instantaneous prediction error; and
5 estimating the measured quantity's variance from the smoothed absolute instantaneous
6 prediction error.

1 27. (Currently Amended) A apparatus for estimating the variance of a measured quantity
2 used to predict the current state of a discrete, vector-state, scalar-measurement system, the
3 method comprising:

4 means for estimating the variance of a measured quantity for use in filtering an input
5 quantity and the measured quantity;

6 means for determining a smoothed estimate of an instantaneous prediction error's final
7 variance; and

8 means for filtering the input quantity and the measured quantity through a Kalman filter
9 using the estimated input variance of the measured quantity signal.

1 28. (Original) The apparatus of claim 27, wherein the means for determining the smoothed
2 estimate of the variance of the instantaneous prediction error of the measured quantity signal
3 comprises:

4 means for determining the squared instantaneous prediction error in the measured
5 quantity signal;

6 means for smoothing the determined, squared instantaneous prediction error; and
7 means for estimating the variance from the smoothed squared instantaneous prediction
8 error.

1 29. (Original) The apparatus of claim 27, wherein the means for determining the smoothed
2 estimate of the variance of the instantaneous prediction error of the measured quantity signal
3 comprises:

4 means for determining the absolute instantaneous prediction error in the measured
5 quantity signal;
6 means for smoothing the determined, absolute instantaneous prediction error; and
7 means for estimating the variance from the smoothed absolute instantaneous prediction
8 error.

1 30. (Currently Amended) A program storage medium encoded with instructions that, when
2 executed by a computing apparatus, perform a method for estimating the variance of a measured
3 quantity used to predict the current state of a discrete, vector-state, scalar-measurement system,
4 the method comprising:

5 estimating the variance of a measured quantity for use in filtering an input quantity and
6 the measured quantity;
7 determining a smoothed estimate of an instantaneous prediction error's final variance;
8 and
9 filtering the input quantity and the measured quantity through a Kalman filter using the
10 estimated input variance of the measured quantity signal.

1 31. (Currently Amended) The program storage medium of claim 30, wherein determining the
2 smoothed estimate of the variance of the instantaneous prediction error of the measured quantity
3 signal in the encoded method comprises:

4 determining the squared instantaneous prediction error in the measured quantity signal;
5 smoothing the determined, squared instantaneous prediction error; and
6 estimating the final variance from the smoothed squared instantaneous prediction error.

1 32. (Currently Amended) The program storage medium of claim 30, wherein determining the
2 smoothed estimate of the variance of the instantaneous prediction error of the measured quantity
3 signal in the encoded method comprises:

4 determining the absolute instantaneous prediction error in the measured quantity signal;
5 smoothing the determined, absolute instantaneous prediction error; and
6 estimating the final variance from the smoothed absolute instantaneous prediction error.

1 33. (Currently Amended) A computing apparatus programmed to perform a method for
2 estimating the variance of a measured quantity used to predict the current state of a discrete,
3 vector-state, scalar-measurement system, the method comprising:

4 estimating the variance of a measured quantity for use in filtering an input quantity and
5 the measured quantity;

6 determining a smoothed estimate of an instantaneous prediction error's final variance;
7 and

8 filtering the input quantity and the measured quantity through a Kalman filter using the
9 estimated input variance of the measured quantity signal.

1 34. (Original) The computing apparatus of claim 33, wherein determining the smoothed
2 estimate of the variance of the instantaneous prediction error of the measured quantity signal in
3 the programmed method comprises:

4 determining the squared instantaneous prediction error in the measured quantity signal;
5 smoothing the determined, squared instantaneous prediction error; and
6 estimating the variance from the smoothed squared instantaneous prediction error.

1 35. (Original) The computing apparatus of claim 33, wherein determining the smoothed
2 estimate of the variance of the instantaneous prediction error of the measured quantity signal in
3 the programmed method comprises:

4 determining the absolute instantaneous prediction error in the measured quantity signal;
5 smoothing the determined, absolute instantaneous prediction error; and
6 estimating the variance from the smoothed absolute instantaneous prediction error.